Nexus between Transport Infrastructure and Sustainable Economic Growth: A perspective of the Northern States of India

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[Abstract] The development of transport infrastructure facilities assists economic growth by improving productivity and creating fair, competitive space. Looking at the national and strategic importance of the transportation network and in pursuance to take forward the existing literature on transport growth, the present study investigates the relationship of transportation infrastructure with sustainable economic development in the nine Northern Indian states. As per the availability, the data has been collected for the period of 17 years ranging from the year 2003-2019. The extensive review testifies to the novelty of the present research work, as previous studies have not analyzed the influence of transport infrastructure networks on the economic growth in the states, namely, Chandigarh, Delhi, Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab, Rajasthan, Uttar Pradesh and Uttarakhand. Here transport infrastructure has been defined as road and railway infrastructure, and gross state domestic product is considered a proxy for growth. Using the GLS panel fixed effect model, the study concludes that the transportation infrastructure significantly and positively impacts the gross state domestic product.

[Keywords] transport infrastructure, road and railway infrastructure, economic growth, panel data analysis, fixed effect model

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Introduction

Transport infrastructure, encompassing roadways, railways, airports and seaports, has a high potential pay-off in economic growth. It is a well-established fact that the availability of adequate infrastructure is vital for the acceleration of the sustainable economic development of a country. It influences the growth of the economy both indirectly and directly (WBR, 1994**;** Bhatta & Drennan, 2003; Lakshmanan, 2007; Condeco-Melhorado et al., 2014; Alvarez-Ayuo et al., 2016; Goldmann & Wessel 2020; Qi et al., 2020). The World Development Report states that adequate and quality infrastructure influence the marginal productivity of capital through – reduced cost of production and structural impacts on demand and supply (Kessides & Ingram, 1995)**.** Potential improvement in transport networks and service lead to a reduction of costs of transport and enhancement of accessibility, which will not only directly lessen the cost of input factors, escalate private financing, vitalize trade, and lead to job creation but also covertly enhances productivity and improves output that ultimately culminates in better overall economic performance (Deng, 2013)**.** Lower cost of production, in turn, impacts the level of work, income and profitability. Infrastructure plays a role in the overall development of a nation, including economic development (Button, 1998)**,** social development (Prud'Homme, 2004), agriculture development, regional development (Ghosh & De, 1998)**,** income distribution (Calderón, & Servén, 2004**)** and poverty reduction (Dercon et al., 2009)**.** Conversely, a lack of infrastructure slows economic development and downgrades the priority of setting up new industries

(World Bank, 1994). Due to its substantial contribution to boosting economic growth, research in this domain holds considerable importance at policymaker and economist desks (Cigu et al., 2019).

In India, the transport infrastructure sector gained tremendous growth in the past few years, and it is undergoing a remarkable resurgence as it is attracting substantial investment. It is expected to grow by 5.9%, becoming the fastest-growing area of India's entire infrastructure sector. The government of India is taking various initiatives, like the Bharatmala project, electrification of railway tracks, introduction of high-speed trains, elevated corridors, focus on reducing carbon emissions, improved land acquisition process, PPP model for investments, attracting private investments, etc. Investments are being lured using various innovative measures, like the hybrid annuity model, toll-operate-transfer model, masala bonds, and infrastructure investment trusts, among other criteria. A well-integrated network creates returns through macroeconomic drivers like the expanse of business activity, competition, innovation, and increase in global mobility, thus enhancing trade, lessening emissions and mortalities as the efficiency of vehicles increases, thus contributing to sustainable economic growth. All these initiatives together focus on introducing intelligent transport infrastructure, which is imperative for spurring sustainable economic growth through the increased contribution of the transport sector to India's GDP. The academic literature has also shown keen interest in exploring the relationship between transport infrastructure development and economic growth, but the observations are mixed. These studies have been conducted in India and abroad. None of the studies has focused on exploring the relationship in Northern India.

The current study endeavors to bridge this research gap by measuring the impact of transport infrastructure development on the growth of the economies of Northern India. The paper is subsequently dissected into five key sections. Section 2 presents a detailed overview of the existing literature in the subject area. Section 3 gives the theoretical framework of data, research methodology and variables used in the research. Section 4 presents the result and discussion of the analysis. Section 5 concludes the empirical results, discusses the research's implications, and highlights the prospects in the respective topic.

Literature Review

This section reviews the extensive literature on transport infrastructure and GDP (economic growth). Many studies, including Apurv & Uzma (2020), Badalyan et al. (2014), Farhadi (2015), Mohmand et al. (2017), Vlahinić et al. (2018), and Wang et al. (2020) have statistically tried to analyze the effect of transportation infrastructure on economic growth. Ke et al. (2020) found a positive impact of transport infrastructure development on the regional growth in the Chinese economy from 2007 to 2015. Assavavipapan & Opasanon (2016) explored the relationship in Thailand by taking the period from 2005 to 2010. The analysis found that one unit rise in the transportation performance index boosts the GDP per capita by 449.420 Thailand Baht. Farhadi (2015) empirically evaluated the impact of transport on the GDP (economic growth) in the group of 18 OECD countries between 1870 and 2009. The result showed a positive influence of change in infrastructure on labor and total factor productivity. Mačiulis et al. (2009) assessed the favorable and unfavorable impact of the transport sector on Lithuanian economy. The study's findings revealed an incremental contribution of the transport sector toward GDP over the years.

Most recently, Apurv & Uzma (2020) investigated the effect of investment in infrastructure development on GDP (economic growth) for BRICS countries for 38 years, i.e. from 1980 the up to 2017. The study concludes a positive association between investment in transport infrastructure and economic growth in Russia and a negative association with the Chinese economy. Some studies have focused on air transport. Balsalobre-Lorente et al. (2021) examined the connection between air transport and economic growth in Spain during 1970-2015. The empirical evidence exhibits positive and significant implications for economic growth. Goldmann & Wessel (2020) quantified the direct and indirect economic growth effect of the Trans European Transport Network on Eastern European countries. The panel and spatial analyses indicated a higher percentage point of GDP if an area has direct access to the new road. It was concluded that better connectivity between regions enhances regional welfare. Hakim & Merkert (2016) appraised the causal linkages of aviation transport to the economic growth in eight South Asian economies comprising Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka for the period 1973 to 2014. The empirical results show a long-run causal linkage between GDP, air passenger traffic, and freight activity.

Taghvaee et al. (2019) examined the impact of maritime and air transportation in the short and long run on the economy of Iran. The study witnessed a low economic growth elasticity in marine transport relative to air transport. Focusing on roads and railways, Wang et al. (2020) studied the impact on the GDP (economic growth) in 65 Belt and Road Initiative (BRI) countries, considering data for the period 2007 to 2016. The study's findings revealed a significant positive effect at the national level. Vlahinić Lenz et al. (2018) empirically explored the growth effect of transportation infrastructure across 11 Central and Eastern European Member States. Conclusively the research identified a favorable and significant impact of road infrastructure on GDP (economic growth) and found a negative and weak effect of railway infrastructure on (GDP) economic growth. Tripathi & Gautam (2010) used annual data for the period 1970-71 to 2007-08 to measure the impact of road transport on GDP (economic growth).

Road transport was measured using the length of roads, national highways, and state highways. The results stated the long-term relationship between road transport network dynamics externalities and GDP. Ng et al. (2019) analyzed the contribution of the infrastructure of road development to GDP (economic growth). Using fixed effects panel linear regression on data from 60 countries over the period 1980 to 2010, the researcher displays that the growth in road length per thousand population contributed positively to the economic growth. Alawin et al., 2013 identified the relationship between economic growth and income distribution.

Overall, it can be concluded that the majority of the analysis done so far found a positive association between transport infrastructure and GDP (economic growth) in countries, including Russia, Spain, Central and Eastern European countries, Iran, Thailand, and 18 OECD countries. A negative association was identified between the Chinese economy and East Asia and Central Asia. However, one study found a positive relationship in China, as well. Further, the casual linkages were established between aviation transport and economic growth in eight South Asian economies comprising Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka. Further, sufficient shreds of evidence are not found in the Indian economy, particularly in the Northern states of India. Therefore, the current study aims to fill the gap by examining the association between transportation infrastructure and GDP (economic growth) in northern states.

Based on the literature review, the following hypotheses are formulated:

H1 Road infrastructure development has a significant relationship with the GSDP (gross state domestic product) of the Northern states of India

H2 Railway Infrastructure development has a substantial relationship with GSDP (gross state domestic product) in the Northern states of India

Methodology

Data and Variable

The present study focuses on nine Northern Indian states: Chandigarh, Delhi, Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab, Rajasthan, Uttar Pradesh, and Uttarakhand. Rail and road transport has been used as a proxy for transport infrastructure. These variables are widely accepted indicators of transportation infrastructure (Badalyan et al., 2014; Vlahinić Lenz et al., 2018; Goldmann & Wessel, 2020; Wang et al., 2020). There are other metrics to measure the transportation infrastructure, such as airport infrastructure; however, these metrics are not available at the state level. Thus, it has been excluded from the study. Gross state domestic product (GSDP) has been used as a proxy for sustainable economic development. The panel data has been collected for a duration of 17 years ranging from 2003 to 2019, from the latest available *Handbook of Statistics on Indian States* published by the Reserve Bank of IndiaThe variables are divided into three categories: experimental variable that includes gross state domestic product (GSDP) measured at constant 2011-2012 (Badalyan et al. (2014)**;** Saidi & Hammami (2017); Saidi et al. (2018); Gherghina et al. (2018); Taghvaee et al., 2019); Control variable that includes total population (TPOP), Population Urban (POPURBAN), Gross Fixed Capital Formation (GFCF) measured in thousands, in thousand and lakhs, respectively (Saidi & Hammami (2017); Balsalobre-Lorente et al. (2021); Badalyan et al. (2014); Vlahinić Lenz et al. (2018); Apurv & Uzma (2020) and Explanatory Variable include Rail and Road measured in length in Km Badalyan et al. (2014); Vlahinić Lenz et al. (2018); Goldmann & Wessel (2020); Wang et al. (2020).

Model Specifications

To spot the relationship of transportation infrastructure with economic growth (GDP), the following model is proposed:

$$lngsdp_{it} = \beta_0 + \beta_1 lnrail_{it} + \beta_2 lnroad_{it} + \beta_3 gfcf_{it} + \beta_4 tpop_{it} + \beta_5 popurban_{it} + \lambda_t + a_i + u_{it}$$

Where $lngsdp_{it}$ is the logarithmic value of GSDP (gross state domestic product) for the states i the cross-sectional unit and time duration t,

$lnrail_{it}$ is the logarithmic value of rail length for the states i and time duration t,

$lnroad_{it}$ $rail_{it}$ Is the logarithmic value of road length for the states i and time duration t,

$gfcf_{it}$ is the value of gross fixed capital formation for the states i and time duration t,

$tpop_{it}$is the total population for the states i and time duration t, $popurban_{it}$ is the urban population for the states i and time duration t.

λ_t represents the unobservable time effect a_i Signify unobservable time-invariant individual effect, u_{it} is the stochastic error term (Vlahinic Lenz et al., 2018) and $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ are the coefficients.

The panel data controls the unobservable heterogeneity and offers consistent coefficient estimates. According to Baltagi (2005), if these limitations are not handled, it might lead to spurious results. Therefore, to remove the endogeneity, the panel regression methodology has been used to inspect the impact of transportation infrastructure on the GDP (sustainable economic growth). The hypothesis parameter is estimated using generalized least square- fixed effect and random effect methods. The fixed effect method is prioritized over OLS as it controls the variable omitted biasness and endogeneity (Roodman, 2009**).** The OLS estimation of panel data does not include the regional and unobserved time effect. This makes the estimations biased and inconsistent, as a positive relationship exists between the lagged variable and the error term (Ding et al., 2008). Further, the Hausman Test was applied to test the appropriateness of the fixed or random effect method. The accuracy of findings relies upon the underlying assumptions of the model. Further, autocorrelation and heteroskedasticity were tested to validate the hypotheses of multicollinearity.

Result and Discussion

Descriptive Statistics and Correlation Matrix

Table 1 presents the descriptive statistics of the experimental, explanatory, and control variables under study. Road infrastructure (LnRoad) has a mean value of 10.705, with a minimum value of 7.40 and a maximum value of 12.98. The average rail transport (LnRAIL) is 6.405, the total weight is 9.12, and the minimum value is 2.07. Gross state domestic product (LnGSDP) has an average value of 16.49 with a maximum and minimum value of 18.39 and 13.76, respectively.

Table 1

Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation
LnGSDP	13.7632	18.3945	16.496633	1.1328428
LnRoad	7.4006	12.9853	10.705661	1.3653997
LnRAIL	2.0794	9.1234	6.405102	1.9074836
GFCF	3070	2521418	486309.70	525909.237
TPOP	901	199812	38147.72	55242.421
POPURBAN	596	44495	10439.62	11828.435

To confirm the likelihood of the presence of multi-collinearity, Pearson's correlation and VIF test are employed. Correlation coefficients are used to measure the strength and direction of the linear relationship between the variables. As evident from Table 2, the dependent variable is positively correlated to the independent variables. It means that the coefficients of the total population and population urban and transport infrastructure have a solid linear positive relationship.

Table 2

Correlation Matrix

	LnGSDP	LnRAIL	LnRoad	GFCF	TPOP	POPURBAN
LnGSDP	1	.840**	.844**	.661**	.649**	.766**
LnRAIL	.840**	1	.929**	.675**	.695**	.673**
LnRoad	.844**	.929**	1	.630**	.696**	.680**
GFCF	.661**	.675**	.630**	1	.628**	.597**
TPOP	.649**	.695**	.696**	.628**	1	.955**
POPURBAN	.766**	.673**	.680**	.597**	.955**	1

*** Correlation is significant at the 0.01 level (2-tailed).*

Table 3 shows the results of variance inflation factors (VIF). All variables, including experimental and explanatory variables, are within range of 10, thus confirming the average level of collinearity (Chu, 2012). Though high VIF was observed for control variables TPOP (12.20704) and POPURBAN (11.31526), since these are not collinear with the variable of interest, there is no problem (Allison, 2012).

Table 3

Variance Inflation Factors

Variable	Coefficient Variance	Uncentered VIF	Centred VIF
C	0.087047	203.0663	NA
LNROAD	0.001776	482.4305	7.665533
LNRAIL	0.000944	97.76799	8.024782
GFCF	3.23E-15	3.674736	1.989205
TPOP	1.78E-12	18.01277	12.20704
POPURBAN	3.60E-11	20.16647	11.31526

Model Testing

Regression Analysis: Generalized least square method (fixed effect). Table 4 shows the generalized least square (fixed effects) model results. T- statistics probability value of road and rail transport infrastructure is significant at a 95% level of confidence. The positive value of the coefficient signifies a significant positive impact of rail infrastructure and road infrastructure on the gross state domestic product of the nine states. A P-value of *t*- statistics in the case of TPOP is 0, which is significant at a 95% significance level. The TPOP coefficient is negative, implying that it has a negative relationship with the gross state domestic product. In the case of POPURBAN, the *t*- statistics probability value is 0, which is significant at a 95% significance level. GFCF's *t*- statistics p-value is 0.0001, which is substantial at a 95% confidence level. The adjusted R-squared value is 0.984889, indicating the model's desirability. In the table, the overall F- statistics is 0, which is significant at a 95% significance level.

Table 4

Fixed Effect Model -Relationship with GSDP

Dependent Variable: LNGSDP				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	9.913701	0.507242	19.54433	0.0000
LNRAIL	0.211567	0.063278	3.343455	0.0011
LNROAD	0.474184	0.060463	7.842562	0.0000
GFCF	2.13E-07	5.10E-08	4.172264	0.0001
TPOP	-4.67E-05	1.06E-05	-4.392202	0.0000
POPURBAN	0.000172	3.64E-05	4.724355	0.0000
Weighted Statistics				
Root MSE	0.174873	R-squared		0.986355
Mean dependent var	21.01681	Adjusted R-squared		0.984889
S.D. dependent var	8.540006	S.E. of regression		0.184713
Sum squared resid	4.128366	F-statistic		672.8069
Durbin-Watson stat	0.589443	Prob(F-statistic)		0.000000
Unweighted Statistics				
R-squared	0.972534	Mean dependent var		16.46307
Sum squared resid	4.589093	Durbin-Watson stat		0.389448

Generalized Least Square Method (Random Effect): Table 5 shows the results of the random effect model. The road infrastructure significantly and positively impacts the GSDP of the nine states. The coefficient value is positive, signifying a significant impact on the gross state domestic product of the nine states. The value of the coefficient is negative, implying a negative relationship with gross state domestic product. T- Statistics probability value of LNROAD (the indicator of road infrastructure) is 0 which is significant at 95% level of significance and the value of coefficient is positive. The t- statistics probability value of rail infrastructure is 0.0001 which is less than 5% and thus significant at 95 % level of significance. P-value of t- statistics of TPOP is 0, compelling at a 95% significance level. The t-statistics probability value of POPURBAN is 0, essential at a 95% significance level. The t-statistics p-value of GFCF is 0, which is significant at a 95% significance level. The adjusted R-squared value is 0.8235, which shows the model's desirability. The overall *F*- statistics are important at a 95% confidence level, thus testifying to the overall significance of the model.

Table 5

Random Effect- EGLS-Relationship with dependent variable GSDP

Dependent Variable: LNGSDP				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	10.51263	0.470198	22.35789	0.0000
LNRAIL	0.205245	0.049153	4.175669	0.0001
LNROAD	0.389582	0.063265	6.157984	0.0000
GFCF	2.52E-07	5.70E-08	4.423708	0.0000
TPOP	-2.95E-05	2.84E-06	-10.36454	0.0000
POPURBAN	0.000141	1.24E-05	11.43021	0.0000
Weighted Statistics				
Root MSE	0.201234	R-squared		0.830139
Mean dependent var	5.513415	Adjusted R-squared		0.823555
S.D. dependent var	0.490082	S.E. of regression		0.205861
Sum squared resid	5.466839	F-statistic		126.0886
Durbin-Watson stat	0.356211	Prob(F-statistic)		0.000000

Finally, the Hausman test is conducted to choose the best model based on the result of the panel least square method fixed effect and panel least square random effect models. The Chi-square p-value is 0.0001, which is significant at a 95% significance level. Therefore, the result of the fixed effect model is preferred over the random effect model. Table 6 presents the development of the Hausman test.

Table 6

Hausman Test

Correlated Random Effects - Hausman Test			
Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	25.633621	5	0.0001

Thus, hypotheses H_1 and H_2, i.e., the road Infrastructure has a significant relationship with the gross state domestic product of the Northern states of India, and the railway infrastructure has a considerable connection with the gross state domestic product of the Northern states of India, respectively, are accepted. The final model that can be framed from the results is as follows:

$$lngsdp_{it} = 9.9137 + 0.2116 lnrail_{it} + 0.4742 lnroad_{it} + 2.13E-07 gfcf_{it} - 4.67E-05 tpop_{it} + 0.0002 popurban_{it} + \lambda_t + a_i + u_{it}$$

Conclusion

This paper empirically appraises the association of transport infrastructure and sustainable economic growth in nine northern states of India, including Chandigarh, Delhi, Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab, Rajasthan, Uttar Pradesh, and Uttarakhand. From the analysis mentioned above, transport infrastructure development has significantly and positively impacted the economic growth of the northern states. According to the regression analysis of the panel data using the fixed and random effect models, the impact is validated. Thus, the study supports the findings of Balsalobre-Lorente et al. (2021), Goldmann & Wessel (2020), Vlahinić Lenz et al. (2018), and Farhadi (2015). Gherghina et al. (2018) found a favourable relationship between transport infrastructure and sustainable economic growth.

Similarly, the study concludes a significant positive impact of road infrastructure on the GDP (economic growth) of the nine north Indian states. It supports the finding of Wang et al. (2020**).** In addition, the railway infrastructure has also favorably impacted the GDP (economic growth). The present study's results contradict Vlahinić Lenz et al. (2018**).** The gross fixed capital formation and urban population also have a significant favourable impact on the GSDP. The study supports the finding of Vlahinić Lenz et al. (2018). The total population significantly negatively impacts the state's economic growth. Overall, it is concluded that there is a positive relationship between road and railway infrastructure development and sustainable growth of state GDP. Thus, it is recommended that more investment be made in developing transport infrastructure to ensure sustainable growth of the state as a well-organized and developed network enhances the quality of life of people.

The Academic and Practical Contribution of the Study

This work's findings should be expected to advance to develop a more theoretical and practical description of the relationship between the two constructs. Therefore, this study significantly adds to the existing literature in creating a compelling ground to understand the sector's importance and how it can contribute substantially towards sustainable growth. Further, it highlights the potential that the transport sector holds in oiling the wheels of the economy, as the two are significantly and positively regressed in the model studied in this research.

Limitations of the Study

The research study also bears some limitations. First, the scope limitation is in the regional context, as the findings are limited to the Northern Indian States. Moreover, the timespan was from 2003-2019, per the data availability. So, limited data is also a constraint. Second. transport infrastructure encompassed roadways and railways only as per the availability of data for airport infrastructure at the state level. In the future, the researchers can expand the sample to include more states. The size of the sample, when increased, might improve the quality and robustness of the results. Third, region-wise analysis can be done within India to test the effect of transport infrastructure on the growth of regional economies.

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